Case Report

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Case Report of Efficacy of Skin Perfusion After Hyperbaric Oxygen Therapy Following Peripheral Tissue Injury due to Usage of Inotropes and Vasopressors

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Abstract: Hyperbaric Oxygen Therapy (HBOT) has garnered significant attention as a therapeutic principle with potential benefits across a variety spectrum of medical conditions, ranging from wound healing and ischemic conditions to neurologic disorders and radiation-induced tissue damage. HBOT involves the administration of 100% oxygen at higher atmospheric pressures, leading to increased oxygen dissolved in bodily fluids and tissues. The elevated oxygen levels are proposed to facilitate tissue repair, reduce inflammation, and promote angiogenesis. This case report presents a compelling instance of the usefulness of HBOT in promoting skin perfusion and healing following peripheral tissue injury resulting from the administration of inotropic and vasopressor agents in septic shock patients.

Keywords: Hyperbaric oxygen therapy; Skin perfusion; Inotropes; Vasopressor

What is already known
Peripheral tissue injury due to the usage of inotropic and vasopressor agents is a challenging clinical scenario marked by impaired perfusion, delayed wound healing, and increased risk of infection. HBOT has been suggested to enhance tissue oxygenation, stimulate angiogenesis, and accelerate wound repair.

What is new in the current study
This case report highlights the effectiveness of Hyperbaric Oxygen Therapy in improving skin perfusion in a patient with peripheral tissue injury due to inotropic and vasopressor use. Further research, including controlled trials, is essential to establish standardized protocols and to confirm the broader applicability of HBOT in similar clinical scenarios.
Introduction

Tissue injury due to the usage of inotropic and vasopressor agents is a challenging clinical scenario marked by impaired perfusion, delayed wound healing, and increased risk of infection. The occurrence is relatively infrequent, documented to be below 2% in certain case reports, yet it may manifest in critically ill patients receiving life-saving vasopressor therapy (1). The severity of the wound can be categorized using the SVS WIFi score, introduced in 2013. This scoring system assesses the degree of tissue engagement, encompassing ischemic alterations, necrosis, infection, and ulceration in the impacted digits (2). Treatment approaches involve early recognition and withdrawal of vasopressors, applying topical nitroglycerin ointment, administering intravenous prostaglandin E1 (PGE1), conducting wound debridement, and, in severe cases, considering vascular surgery or amputation (3). Furthermore, hyperbaric oxygen therapy (HBOT) has been recently suggested to enhance tissue oxygenation, stimulate angiogenesis, and accelerate wound repair (4). This case report highlights the effectiveness of HBOT in a patient with severe peripheral tissue injury following inotropic and vasopressor administration.

Case Presentation

A 64-year-old female with diabetes mellitus and recent history of epidural steroid injection (L2 level) visited the emergency center due to severe dyspnea, lumbago, and xerostomia. She was diagnosed with septic shock due to hypervirulent klebsiella pneumoniae, iatrogenic emphysematous osteomyelitis at L2, and paravertebral abscess of right psoas. The patient was immediately admitted to the emergency intensive care unit (EICU) for management of hemodynamic instability. During her EICU stay, the patient had undergone continuous renal replacement therapy (CRRT) and mechanical ventilation (MV) care as well as intravenous (IV) multi-antibiotic therapy. Inotropic agent and vasopressor (Norepinephrine at highest dose of 60 mcg/min, vasopressin as highest dose of 5 IU/hr) were initiated to maintain adequate blood pressure and cardiac output. The vasopressin was completely tapered on the first day of hospital admission, and norepinephrine was fully tapered by the 11th day of hospitalization.

Over the course of her EICU stay, the patient developed peripheral tissue injury on the bilateral lower
extremities on her 12th hospital day, characterized by dusky skin and decreased capillary refill time [Figure 1]. The wound was considered to fall into grade 2 in SVS WfII classification system, clinically described as major tissue loss. The gangrenous change of both feet was further evaluated with ankle-brachial index (ABI) in order to rule out peripheral arterial disease (PAD), which is characterized by reduced blood flow to the limbs due to atherosclerosis or other vascular conditions. The ABI results revealed normal values, with a left ankle ABI of 1.33 and a right ankle ABI of 1.30 [Figure 2]. This outcome strongly suggested that the manifestation in both feet stemmed from the iatrogenic administration of vasoconstrictors.

Given the compromised perfusion and risk of tissue necrosis, the decision was made to initiate a series of HBOT sessions as soon as the patient’s medical condition allowed for in-ward management. The patient underwent a total of 27 HBOT sessions, each lasting 130 minutes, mono chamber, administered at a pressure of 2.5 atmospheres absolute (ATA) with 100% oxygen. The treatments were well-tolerated, and the patient's vitals remained stable throughout the sessions.

A noticeable improvement in skin perfusion was not directly observed following the 27 HBOT sessions. Furthermore, after her medical condition was nearly recovered enough for outpatient follow-up, she revisited our orthopedic outpatient department every one-or-two months to check up on her peripheral tissue injuries and still did not show evident improvement. Amputation was recommended for foot lesions in the lower extremities but the patient refused.

Ten months following the patient's previous outpatient appointment, she returned to the orthopedics department, and significant progress had been made in the healing of her foot lesions [Figure 3]. No additional treatment was administered during the period of follow-up loss, and the patient reported that she had independently performed self-debridement of hardened skin tissues. The previous areas of necrotic skin showed enhanced capillary refill and gradual return of normal skin coloration. Also, the follow up X-ray image revealed partial self-amputation of distal phalanx in regions where the skin was previously necrotic, following the restoration of normal skin coloration [Figure 4]. The patient reported decreased pain and discomfort associated with the peripheral tissue injury. The total progress of the case report is shown in Table 1.
Discussion

This case report highlights the usefulness of Hyperbaric Oxygen Therapy in improving skin perfusion in a patient with peripheral tissue injury due to inotropic and vasopressor use. The limitation of this case was the restricted assessments of wound healing after the patient was discharged from the hospital. It is assumed that HBOT sessions played a preventive role in halting additional ischemia below joint level, consequently resulting in the auto-amputation of the tip portion of the distal phalanx and the revascularization of remaining wounds. Further research, including controlled trials, is essential to establish standardized protocols and to confirm the broader applicability of HBOT in similar clinical scenarios.

Conclusion

The improvement in skin perfusion observed in this case suggests that HBOT has the potential to enhance tissue oxygenation and angiogenesis in peripheral tissue injuries related to compromised perfusion caused by inotropes and vasopressor administration. HBOT involves breathing 100% oxygen under increased atmospheric pressure, leading to elevated oxygen levels in plasma and tissues. This increased oxygen availability directly supports cellular metabolism and promotes wound healing (5). HBOT also augments the diffusion of oxygen in tissues with compromised blood flow, which is crucial for providing oxygen to areas with limited circulation. HBOT triggers the release of growth factors such as vascular endothelial growth factor (VEGF), promoting the formation of new blood vessels (angiogenesis) that improve tissue perfusion (6). Moreover, hyperbaric oxygen therapy can attenuate inflammation by reducing pro-inflammatory cytokines and oxidative stress. This anti-inflammatory effect prevents vasoconstriction and helps maintain blood vessel patency. HBOT can reverse microvascular constriction caused by hypoxia and ischemia. This vasodilation improves blood flow and nutrient delivery to the tissues. Last but not least, HBOT encourages the development of collateral circulation, compensating for compromised blood vessels and contributing to improved skin perfusion. (7) The combined effects of increased oxygen availability, angiogenesis stimulation, inflammation
reduction, and vascular dilation offer a comprehensive explanation for the observed improvements in
wound healing and tissue repair.
Reference


Figure 1. The patient developed peripheral tissue injury on the bilateral lower extremities, characterized by dusky skin and decreased capillary refill time.
Figure 2. Result of ankle-brachial index. The patient showed normal value of ABI (Left ankle ABI 1.33, right ankle ABI 1.30)
Figure 3. The previous areas of necrotic skin showed enhanced capillary refill and gradual return of normal skin coloration.
Figure 4. The X-ray image reveals partial self-amputation of distal phalanx in regions where the skin was previously necrotic, following the restoration of normal skin coloration.
Table 1. Time table of the total progress

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>EICU admission</td>
<td>22.03.04</td>
</tr>
<tr>
<td>Vasopressin start – tapered</td>
<td>22.03.05</td>
</tr>
<tr>
<td>Norepinephrine start</td>
<td>22.03.10</td>
</tr>
<tr>
<td>Extremity ischemic change was noted</td>
<td>22.03.16</td>
</tr>
<tr>
<td>Norepinephrine tapered</td>
<td>22.04.16</td>
</tr>
<tr>
<td>HBOT start</td>
<td>22.06.19</td>
</tr>
<tr>
<td>HBOT 27th session complete</td>
<td>22.06.19</td>
</tr>
<tr>
<td>Discharged from hospital</td>
<td>22.06.19</td>
</tr>
<tr>
<td>Last OPD visit</td>
<td>22.07.20</td>
</tr>
<tr>
<td>Amputation recommended – patient refused</td>
<td>23.08.11</td>
</tr>
<tr>
<td>Return of normal skin coloration of wound</td>
<td></td>
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</tbody>
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